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RESEARCH ARTICLE

Welfare reducing licensing by an outside innovator

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Abstract

It is commonly believed that licensing of cost reducing technology increases welfare. We show that technology licensing by an outside innovator may reduce welfare when the technology is not useful for all final goods producers. Technology licensing reduces welfare if cost reduction by the licensed technology is small and the initial cost difference of the final goods producers is large. A higher intensity of competition, either due to lower product differentiation or due to Bertrand competition instead of Cournot competition, increases the possibility of welfare reducing licensing.

Keywords Auction · Fixed-fee · Outside innovator · Technology licensing · Welfare

JEL Classification D44 · D45 · L13

1 Introduction

It is usually believed that technology licensing increases welfare by improving cost efficiency in the industry. However, this view is being challenged in recent decades. There is a literature showing that licensing by inside innovators, where the innovators license their technologies and compete with the licensees, may reduce welfare compared to no licensing. This happens if it facilitates a collusive outcome (La Manna 1993; Faulí-Oller and Sandonis 2002; Erkal 2005), affects R&D (Mukherjee 2005;

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Chang et al. 2013), creates excessive entry (Mukherjee and Mukherjee 2008), changes the mode of entry of the foreign firm (Sinha 2010), increases (decreases) the government's subsidy bill (tax revenues) (Ghosh and Saha 2015) and creates production inefficiency when the most efficient firm is not the licenser (Creane et al. 2013).

We provide a new perspective to the literature on welfare reducing licensing by showing that licensing by an outside innovator, where the innovator licenses its technology but does not compete with the licensee, may also reduce welfare.

We consider a situation where two asymmetric-cost final goods producers compete in the product market, and an outside innovator has a cost reducing innovation that reduces the cost of the high-cost producer only. The outside innovator licenses its technology to the final goods producers either through auction or through fixed-fee. Hence, we follow the structure developed by Stamatopoulos and Tauman (2009). In this framework, the high-cost producer will acquire the technology of the outside innovator, although the low-cost producer will try to pre-empt the high-cost producer from purchasing the technology. Licensing will reduce welfare if cost reduction by the licensed technology is small and the initial cost difference of the final goods producers is large. A higher intensity of competition, either due to lower product differentiation or due to Bertrand competition instead of Cournot competition, increases the possibility of welfare reducing licensing.

The implications of production inefficiency are well studied in other areas, such as entry (Klemperer 1988 and Lahiri and Ono 1988, Mukherjee and Mukherjee 2005), trade liberalisation (Brander 1981; Brander and Krugman 1983; Collie 1996; Clarke and Collie 2003), merger (Faulí-Oller and Sandonís, 2003), and patent protection (Bagchi and Mukherjee 2021). However, the technology licensing literature, which can be a natural area for this aspect due to its focus on asymmetric-cost firms, didn't pay much attention to this aspect by assuming that the new technologies are useful for all the producers. Although Stamatopoulos and Tauman (2009) relaxed this assumption to explore the possibility of technology licensing when the technology is not useful for the efficient firm, they did not consider the welfare effects of licensing.

In the context of inside innovators, Creane et al. (2013) showed the implications of production inefficiency under licensing. However, welfare reducing licensing does not occur in their model with duopoly producers, while we show the welfare reducing licensing under an outside innovator with duopoly producers. This difference arises because the production inefficiency effect does not occur in their inside innovator model with duopoly producers. Further, Creane et al. (2013) considered only Cournot competition among the producers and did not look at the implications of Bertrand competition.

In a recent paper, Lu and Poddar (2023) consider licensing and patent shelving in a Hotelling model with inelastic demand, full market coverage, price competition in the product market, an outside innovator, different absorptive capabilities of the licensees, and two-part tariff licensing contracts. They show that licensing may reduce welfare if licensing with a two-part tariff contract to the efficient licensee occurs, which creates shelving. Licensing in their analysis is always welfare improving under no shelving.

In contrast to Lu and Poddar (2023), we consider elastic demand with full absorptive capabilities and no royalty payments (which may happen due to the problem of imitation or output verifiability (see, e.g., Rockett 1990)). In our analysis, the inefficient licensee acquires the technology of the outside innovator, i.e., there is no shelving, and licensing may reduce welfare. This result holds under both quantity and price competition in the product market. Hence, Lu and Poddar (2023) show that the welfare reducing licensing may occur provided there is shelving of the licensed technology, while the welfare reducing licensing occurs in our analysis without shelving.

The remainder of the paper is organised as follows. Section 2 describes the model and shows the results. Section 3 concludes.

2 The model and the results

We consider a licensing game similar to Stamatopoulos and Tauman (2009). Assume that there are two firms—firm 1 and firm 2—competing in the product market. Assume that firm 1's marginal cost of production is zero and firm 2's marginal cost of production is c. Hence, c measures cost difference of the final goods producers.

There is an outside innovator, called firm 0, which has a technology that can reduce the cost of production of firm 2 from c to $(c - \varepsilon) > 0$. Hence, the technology of firm 0 cannot affect the marginal cost of firm 1.

The structure of the licensing game is as follows. In stage 1, firm 0 announces the licensing scheme. It can license the technology either through a fixed fee or through auction. In stage 2, depending on the licensing scheme—fixed fee or auction—firms 1 and 2 decide whether to purchase the technology by paying the appropriate fee. They purchase the technology if they are not worse off by purchasing than not purchasing the technology. In stage 3, firms compete in the product market like Cournot duopolists. We solve the game through backward induction. We will show the implications of Bertrand competition in the Online Appendix.

Even if the technology of firm 0 cannot reduce the marginal cost of firm 1, firm 1 may still want to purchase the technology to pre-empt firm 2 from purchasing it. As discussed below, this may depend on the licensing scheme adopted by firm 0.

It is worth noting that like the implicit assumption of Stamatopoulos and Tauman (2009), we assume that technology transfer from firm 1 to firm 2 is economically non-viable. There could be several reasons for it. The technology of firm 1 may not be compatible with the product of firm 2. The resource cost of licensing the technology of firm 1 to firm 2 may be prohibitive.[1] However, technology transfer from firm 0 to firms 1 and 2 are assumed to be economically viable due to non-prohibitive resource costs of technology transfer and the technology of firm 0 is assumed to be compatible with the product of firm 2. For simplicity, we assume that the costs of transferring the technology of firm 0 to firms 1 and 2 are zero and the cost of transferring the technology of firm 1 to firm 2 is prohibitive.

For our analysis, we will consider the demand functions similar to Singh and Vives (1984), which is widely used in the literature. However, we will also show the general expression for the welfare implications of licensing.

[1] As documented in Teece (1976) and Arora et al. (2001), technology licensing involves significant amount of cost due to contract formation and enforcement. Further, a better technology involves higher cost of technology transfer.

Assume that the utility function of a representative consumer is $U = q_1 + q_2 - \frac{q_1^2+q_2^2+2\gamma q_1 q_2}{2}$, where q_1 and q_2 are the outputs of firms 1 and 2 respectively. The parameter $\gamma \in [0,\ 1]$ measures the degree of product differentiation. The products are regarded as independent if$\gamma = 0$, whereas the products are regarded as perfect substitutes if$\gamma = 1$.

As shown by Amir et al. (2017), the inverse demand function and the direct demand function are well behaved if the quadratic utility function is strictly concave. If the quadratic utility function is not strictly concave, the direct demand function need not be well defined. The utility function $U = q_1 + q_2 - \frac{q_1^2+q_2^2+2\gamma q_1 q_2}{2}$ is strictly concave for $\gamma \in [0,\ 1)$. Hence, to consider competition between the firms, we will consider $\gamma \in (0,\ 1]$ under Cournot competition, and to consider competition between the firms and to avoid the problem mentioned by Amir et al. (2017), we will consider under Bertrand competition that $\gamma \in (0,\ 1)$, which will also avoid the well-known "Bertrand paradox".

The above-mentioned utility function generates the inverse market demand function $P_i = 1 - q_i - \gamma q_j$, i, j = 1, 2; i $\neq$ j, where P_i stands for the price of the ith firm's product, and q_i and q_j are the outputs of the ith and jth firms respectively.

2.1 No licensing

If the firms produce with their own technologies, firms 1 and 2 determine their outputs to maximise $\underset{q_1}{Max}\ P_1 q_1 = \underset{q_1}{Max}(1 - q_1 - \gamma q_2)q_1$ and $\underset{q_2}{Max}(P_2 - c)q_2 = \underset{q_2}{Max}(1 - q_2 - \gamma q_1 - c)q_2$ respectively. The equilibrium outputs can be found as $q_1 = \frac{2-\gamma+c\gamma}{4-\gamma^2}$ and $q_2 = \frac{2-2c-\gamma}{4-\gamma^2}$. We assume $c < \frac{2-\gamma}{2} = c_{\max}^{C}$ so that both firms always produce positive outputs. The equilibrium profits of firms 1 and 2 are $\pi_1 = \frac{(2-(1-c)\gamma)^2}{(4-\gamma^2)^2}$ and $\pi_2 = \frac{(2-2c-\gamma)^2}{(4-\gamma^2)^2}$ respectively.

The equilibrium welfare, $W = U(q_1,\ q_2) - cq_2$, is:

$$W = \frac{2(2-\gamma)^2(3+\gamma)-2c(2-\gamma)^2(3+\gamma)+c^2\left(12-\gamma^2\right)}{2\left(4-\gamma^2\right)^2}.$$

2.2 Licensing

Firm 0 can license its technology either through fixed-fee or through auction. Since the analysis under licensing is similar to that of in Stamatopoulos and Tauman (2009), we will analyse the licensing game briefly.

2.2.1 Auction licensing

If firm 0 auctions off an exclusive license through a first-price sealed-bid auction, the willingness to pay for the technology by firm i, $i = 1,\ 2$, is the difference between its profit if it acquires the technology and its profit if firm j, $j = 1,\ 2,\ \ i \neq j$, acquires the technology.[2] Hence, firms 1 and 2 want to pay at most for the technology of firm 0 are $B_1 = \pi_1^*(0, c) - \pi_1^*(0, c-\varepsilon)$ and $B_2 = \pi_2^*(0, c-\varepsilon) - \pi_2^*(0, c)$ respectively, where $\pi_i^*(0, c')$ is the equilibrium profit of firm i, $i = 1, 2$, where the first (second) argument in $\pi_i^*(., .)$ shows the marginal cost of firm 1 (firm 2) and $c' \in \{c, c-\varepsilon\}$.

It follows from Stamatopoulos and Tauman (2009) that firm 0 will earn $Min\{B_1, B_2\}$ under auction since $B_1 \gtreqless B_2$. In our analysis, $B_1 \gtreqless B_2$ under Cournot competition for $\varepsilon \lesseqgtr \left(-2 + 2c + \frac{8\gamma}{4+\gamma^2}\right)$.

2.2.2 Fixed-fee licensing

Under fixed-fee licensing, firm 0 charges a fixed-fee for the technology and any firm that pays the fee can purchase it. Under fixed-fee, firm 2's maximum willingness to pay for the technology is $B_2 = \pi_2^*(0, c-\varepsilon) - \pi_2^*(0, c)$, and firm 0 will charge it for the following reason.

If the fixed-fee is not greater than B_2, firm 2 will purchase it and firm 1 will not be able to pre-empt firm 2 from purchasing it. On the other hand, if the fixed-fee is greater than B_2, firm 2 will not purchase the technology, since the technology is not useful for firm 1 and firm 1's only incentive to purchase the technology is to pre-empt firm 2 from purchasing it. Hence, firm 1 has no incentive to purchase the technology irrespective of the fixed-fee.

Since firm 0 earns $Min\{B_1, B_2\}$ under auction and B_2 under fixed-fee, firm 0 prefers to offer the fixed-fee licensing, since firm 0 earns under fixed-fee licensing at least its payoff from auction. Hence, the following proposition follows from Stamatopoulos and Tauman (2009).

Proposition 1 (Stamatopoulos and Tauman 2009) *Firm 0 offers the fixed-fee licensing contract and only firm 2 purchases the technology of firm 0.*

2.3 Welfare implications of licensing

For a general utility function $U = (q_1, q_2)$, with firm 1's marginal cost being 0, we have welfare under no licensing as $W = U - cq_2$. To understand the welfare effects of licensing, let's see how W changes with c. Since the outputs are functions of c, we get:

$$\frac{\partial W}{\partial c} = \underbrace{\frac{\partial q_2}{\partial c}\left(\frac{\partial U}{\partial q_2} + \frac{\partial q_1}{\partial q_2}\frac{\partial U}{\partial q_1}\right)}_{\substack{\text{Total output raising effect} \\ (-)}} + \underbrace{(-q_2)}_{\substack{Cost\ saving \\ (-)}} + \underbrace{\left(-c\frac{\partial q_2}{\partial c}\right)}_{\substack{\text{Production inefficiency effect} \\ (+)}}. \quad (1)$$

Hence, technology licensing, which reduces the marginal cost of firm 2, creates three effects on welfare. First, it tends to increase welfare by increasing the total outputs of firms 1 and 2, as shown by the first term in the right hand side (RHS) of (1).

[2] Note that firm 0 has no incentive to auction off two licenses, because if it auctions off two licenses, firm 1 will have no incentive to bid for firm 0's technology, since firm 0's technology is not useful for firm 1, and firm 1 will not be able to pre-empt firm 2 from purchasing firm 0's technology.

Second, the cost saving in firm 2 due to a better technology tends to increase welfare, as shown by the second term in the RHS of (1). Third term in the RHS of (1) shows the production inefficiency effect that tends to reduce welfare by helping firm 2 (the high-cost firm) to steal market share from firm 1 (the low-cost firm).

If the initial marginal cost difference of the firms is high (i.e., c is high), the production inefficiency effect is very strong (due to high c) and the cost saving effect is very weak (due to small q_2). On the other hand, if the cost reduction through licensing is small (i.e., ε is low), the total output raising effect is weak. Hence, it is expected that if c is high and ε is low, the production inefficiency effect dominates the other two effects to create the welfare reducing licensing. Now we will show with the functional forms that it is indeed the case.

We can find the outputs, prices, profits and welfare under licensing in the similar way we have derived them in Sect. 2.1 under no licensing but with the exception that c will be replaced by $(c - \varepsilon)$ under licensing.

Proposition 2 *If firms 1 and 2 compete like Cournot duoplists, technology licensing, which reduces the marginal cost of firm 2 from c to* $(c - \varepsilon)$*, reduces welfare if* $c \in (c^C, c^C_{\max})$ *and* $\varepsilon \in \left(0, \varepsilon^C\right)$*, where* $c^C = \left(1 + \gamma\left(-1 + \frac{4}{12-\gamma^2}\right)\right)$*and* $\varepsilon^C = 2\left(-1 + c + \gamma + \frac{4\gamma}{-12+\gamma^2}\right)$.

Proof We get $\Delta W^C = W(c) - W(c-\varepsilon) = \frac{\varepsilon\left(-2(2-\gamma)^2(3+\gamma)+2c\left(12-\gamma^2\right)-\varepsilon\left(12-\gamma^2\right)\right)}{2\left(4-\gamma^2\right)^2} > 0$ if $\varepsilon < 2\left(-1+c+\gamma-\frac{4\gamma}{12-\gamma^2}\right) = \varepsilon^C$ and $\varepsilon^C > 0$ for $c > \left(1+\gamma\left(-1+\frac{4}{12-\gamma^2}\right)\right) = c^C$. Further, $\varepsilon^C < c$ if $c < 2\left(1-\gamma+\frac{4\gamma}{12-\gamma^2}\right)$, which always holds since $c^C_{\max} = \frac{2-\gamma}{2} < 2\left(1-\gamma+\frac{4\gamma}{12-\gamma^2}\right)$. Therefore, we get the welfare reducing licensing if $c \in (c^C, c^C_{\max})$ and $\varepsilon \in (0, \varepsilon^C)$. □

Figure 1 considers $\gamma = 1$, $c = 0.4999$ and $\varepsilon \in [0, 0.4999]$ to provide an example for the welfare reducing licensing under Cournot competition. Positive (negative) ΔW^C shows that licensing reduces (increases) welfare compared to no licensing.[3]

2.3.1 The effects of competition on the welfare reducing licensing

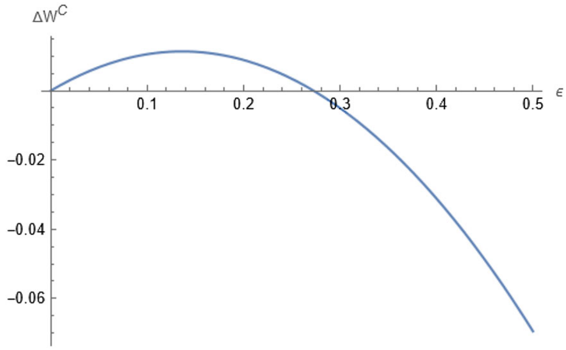
To show how the intensity of competition affects the possibility of welfare reducing licensing, we first examine how γ affects c^C and ε^C.

Proposition 3 *A higher intensity of competition due to lower product differentiation (i.e., due to higher* γ*) increases the possibility of welfare reducing licensing under Cournot competition.*

Proof We get $\frac{\partial c^C}{\partial \gamma} = -\frac{96-28\gamma^2+\gamma^4}{\left(12-\gamma^2\right)^2} < 0$ and $\frac{\partial \varepsilon^C}{\partial \gamma} = \frac{2\left(96-28\gamma^2+\gamma^4\right)}{\left(12-\gamma^2\right)^2} > 0$, implying that, under Cournot competition, a higher γ reduces c^C, which increases the possibility

[3] $c^C(\gamma = 1) = 0.36$, $c^C_{\max} = 0.5$, and $\varepsilon^C(\gamma = 1, c = 0.4999) = 0.27$. Hence, the welfare reducing licensing occurs here for more than 50% of the range of ε considered.

Fig. 1 $\Delta W^C = W(c) - W(c - \varepsilon)$



of satisfying $c > c^C$, and increases ε^C, which increases the possibility of satisfying $\varepsilon \in (0, \varepsilon^C)$. □

Higher intensity of competition makes the production inefficiency effect more relevant and increases the possibility of welfare reducing licensing.

Now we want to see how the type of product market competition, i.e., Cournot or Bertrand competition, affects the possibility of the welfare reducing licensing. Hence, we need to derive c^B and ε^B (which is in the Online Appendix), and need to compare them with c^C and ε^C. The following proposition mentions the result but the mathematical details are in the Online Appendix.

Proposition 4 *The possibility of welfare reducing licensing is higher under Bertrand competition compared to Cournot competition.*

The reason for Proposition 4 is similar to that of Proposition 3 since the intensity of competition is higher under Bertrand competition compared to Cournot competition.

3 Conclusion

It is usually believed that technology licensing increases welfare. However, recent studies challenge this view and show that licensing by inside innovators may reduce welfare. We show in this paper that the welfare reducing licensing may occur for the case of an outside innovator if the technology of the outside innovator is not useful for all final goods producers. Technology licensing reduces welfare if cost reduction through licensing is small and the initial cost difference of the producers is large. Further, a higher intensity of competition, either due to lower product differentiation or due to Bertrand competition instead of Cournot competition, increases the possibility of welfare reducing licensing.

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